



(11)

EP 3 712 415 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

06.03.2024 Bulletin 2024/10

(51) International Patent Classification (IPC):

F02C 9/30 ^(2006.01) **F02C 9/00** ^(2006.01)
F02C 9/28 ^(2006.01) **F02C 7/232** ^(2006.01)
F02C 7/236 ^(2006.01)

(21) Application number: **18877938.3**

(52) Cooperative Patent Classification (CPC):

F02C 7/232; F02C 7/236; F02C 9/30;
F05D 2270/3015; F05D 2270/304; F05D 2270/306;
F05D 2270/706; F05D 2270/708

(22) Date of filing: **05.10.2018**

(86) International application number:

PCT/JP2018/037399

(87) International publication number:

WO 2019/097894 (23.05.2019 Gazette 2019/21)

(54) **FUEL SUPPLY CONTROL DEVICE**

KRAFTSTOFFVERSORGUNGSSTEUERUNGSVORRICHTUNG

DISPOSITIF DE COMMANDE D'ALIMENTATION EN CARBURANT

(84) Designated Contracting States:

AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR

• **SEKI, Naoki**

Tokyo 135-8710 (JP)

(30) Priority: **16.11.2017 JP 2017220612**

(74) Representative: **MERH-IP Matias Erny Reichl**
Hoffmann

Patentanwälte PartG mbB
Paul-Heyse-Strasse 29
80336 München (DE)

(43) Date of publication of application:

23.09.2020 Bulletin 2020/39

(56) References cited:

EP-A1- 3 040 277 WO-A1-2015/029805
GB-A- 2 351 777 JP-A- H07 217 821
JP-A- 2013 231 406 US-A- 4 341 071
US-A- 5 220 793 US-A1- 2015 192 073

(73) Proprietor: **IHI Corporation**
Tokyo 135-8710 (JP)

(72) Inventors:

• **YAMAMOTO, Yasuhiko**
Tokyo 135-8710 (JP)

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 3 712 415 B1

Description

BACKGROUND ART

[0001] Patent Document 1 discloses a fuel supply apparatus for a gas turbine engine. The fuel supply apparatus operates a centrifugal pump (low-pressure pump) and a gear pump (high-pressure pump) by controlling and driving a motor (electric motor) with a motor controller (fuel supply control device), and supplies desired fuel to fuel nozzles through parallel flow passages of a fixed orifice and a pressurizing valve. Further, the motor controller takes a front-rear differential pressure across the fixed orifice, that is, the pressurizing valve, which is detected by a differential pressure gauge, as a feedback signal; and performs the feedback control of the electric motor on the basis of a difference between the feedback signal and a command signal that is taken from full authority digital engine control (FADEC) that is a control device electrically controlling an engine for an airplane on the basis of the position of a throttle lever and inputs from various sensors.

Further relevant prior art is described in GB 2 351 777 A.

Citation List

Patent Document

[0002] [Patent Document 1] Japanese Unexamined Patent Application, FirstPublication No. 2013-231406

DISCLOSURE OF INVENTION

Technical Problem

[0003] The fixed orifice and the pressurizing valve function as a metering valve, but there is a possibility that the front-rear differential pressure may be unstable in a high flow-rate range where the pressurizing valve is opened. Accordingly, there is a possibility that it may be difficult to perform stable fuel supply control in the high flow-rate range where the pressurizing valve is opened in the fuel supply control device in the related art.

[0004] The disclosure has been made in consideration of the above-mentioned circumstances, and an object of the disclosure is to achieve stable fuel supply control in a high flow-rate range where a pressurizing valve is opened.

Solution to Problem

[0005] In order to solve the aforementioned problems, it is provided according to a first aspect a fuel supply control device, which has the features defined in claim 1. Further it is provided a fuel supply control device having the features defined in claim 6. Further preferred embodiments are defined in the dependent claims.

Advantageous Effects of Invention

[0006] According to the disclosure, it is possible to achieve stable fuel supply control in a high flow-rate range where a pressurizing valve is opened.

BRIEF DESCRIPTION OF DRAWINGS

[0007]

FIG. 1 is a diagram showing the system configuration of a fuel supply apparatus of an embodiment of the disclosure.

FIG. 2 is a block diagram showing the functional configuration of a fuel supply control device according to an embodiment of the disclosure.

FIG. 3 is a block diagram showing the functional configuration of a fuel supply control device according to a modification example of the embodiment of the disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0008] An embodiment of the disclosure will be described below with reference to drawings.

[0009] A fuel supply apparatus F of this embodiment will be described first with reference to FIG. 1. The fuel supply apparatus F is a device that supplies fuel to a gas turbine G as shown in FIG. 1, and supplies a desired amount of fuel to a plurality of fuel nozzles N of a combustor (not shown) of the gas turbine G.

[0010] The gas turbine G is an internal combustion engine provided in an airplane as a thrust source for flight, and is a jet engine that obtains a thrust by jetting combustion exhaust gas, which is obtained from the combustor, rearward. That is, the fuel supply apparatus F is a device that is provided in an airplane.

[0011] As shown in FIG. 1, the fuel supply apparatus F includes a fuel tank 1, a low-pressure pump 2, a high-pressure pump 3, an electric motor 4, a pressurizing valve 5, an orifice 6, a differential pressure gauge 7, and a fuel supply control device 8. The fuel tank 1 is a container storing a predetermined amount of fuel, and supplies fuel to the low-pressure pump 2. The low-pressure pump 2 is a centrifugal pump (non-positive-displacement pump) that pumps fuel out of the fuel tank 1, increases the pressure of the fuel up to a predetermined pressure, and discharges the fuel to the high-pressure pump 3.

[0012] The high-pressure pump 3 is a gear pump (positive-displacement pump) that increases the pressure of the low-pressure fuel supplied from the low-pressure pump 2 and discharges the fuel to the respective fuel nozzles N as high-pressure fuel. The high-pressure pump 3 is a fuel supply pump of this embodiment that finally sets the amount of fuel to be supplied (fuel supply amount) to the gas turbine G (fuel nozzles N) from the fuel supply apparatus F.

[0013] The electric motor 4 is a power source that ro-

tationally drives the low-pressure pump 2 and the high-pressure pump 3. The output shaft (drive shaft) of the electric motor 4 is coupled to the rotating shaft (driven shaft) of the low-pressure pump 2 and the rotating shaft (driven shaft) of the high-pressure pump 3 through a predetermined coupler (not shown). That is, a certain correlation is satisfied between the rotation speed of the electric motor 4 (motor-rotation speed) and the rotation speed of each of the low-pressure pump 2 and the high-pressure pump 3. Further, the electric motor 4 outputs the motor-rotation speed, which is the rotation speed thereof, to the fuel supply control device 8 as a first detection signal. In this embodiment, for convenience's sake, the motor-rotation speed is treated as the rotation speed of the fuel supply pump.

[0014] The pressurizing valve 5 is provided at a middle portion of a fuel pipe that connects the outlet of the high-pressure pump 3 to the inlets of the fuel nozzles N. The pressurizing valve 5 is closed in a case where the amount of fuel to be discharged from the high-pressure pump 3 is relatively small, and is opened in a case where the amount of fuel to be discharged from the high-pressure pump 3 exceeds a predetermined value. As with the pressurizing valve 5, the orifice 6 is provided at the middle portion of the fuel pipe that connects the outlet of the high-pressure pump 3 to the inlets of the fuel nozzles N.

[0015] As shown in FIG. 1, the pressurizing valve 5 and the orifice 6 form parallel flow passages through the fuel pipe. That is, both the inlet of the pressurizing valve 5 and the inlet of the orifice 6 are connected to the outlet of the high-pressure pump 3 through the fuel pipe, and both the outlet of the pressurizing valve 5 and the outlet of the orifice 6 are connected to the inlets of the fuel nozzles N through the fuel pipe. The pressurizing valve 5 and the orifice 6 constitute a metering valve that detects the flow rate of fuel (fuel supply amount) to be supplied to the fuel nozzles N from the high-pressure pump 3.

[0016] The differential pressure gauge 7 is a differential pressure transmitter that detects differential pressure between the upstream side (inlet side) and the downstream side (outlet side) of each of the pressurizing valve 5 and the orifice 6 as a front-rear differential pressure. This front-rear differential pressure is pressure amount that changes depending on the flow rate of fuel, that is, a motor-rotation speed; that is, a physical quantity that corresponds to the flow rate of fuel. The differential pressure gauge 7 outputs the front-rear differential pressure to the fuel supply control device 8 as a second detection signal.

[0017] The fuel supply control device 8 controls the electric motor 4 on the basis of the first detection signal (motor-rotation speed) and the second detection signal (front-rear differential pressure) having been described above and a control target value. The fuel supply control device 8 is a software control device that generates an operation amount of the electric motor 4 by executing a predetermined rewritable control program with predetermined hardware. The hardware includes a storage device that stores a control program and the like, a central

processing unit (CPU) that directly executes a control program, an interface circuit and the like that is interposed between the CPU and the electric motor 4 and between the CPU and the differential pressure gauge 7 and transmits and receives various signals. Further, the fuel supply control device 8 is electrically connected to the electric motor 4 and the differential pressure gauge 7.

[0018] The fuel supply control device 8 includes a differential pressure-fuel supply amount conversion table 8a, a rotation speed-fuel supply amount conversion table 8b, a leakage amount estimation unit 8c, an adder 8d, a switching logic circuit 8e, a selection switch 8f, a subtractor 8g, and a control calculation unit 8h shown in FIG. 2, as functional components that are embodied by the cooperation of the control program (software) and the hardware.

[0019] The differential pressure-fuel supply amount conversion table 8a is a control table showing a relationship between the front-rear differential pressure that is input from the differential pressure gauge 7 as the second detection signal and the amount of fuel (fuel supply amount) to be supplied to the fuel nozzles N (gas turbine G) from the fuel supply apparatus F. That is, the differential pressure-fuel supply amount conversion table 8a includes a plurality of fuel supply amount data (data group) that correspond to a plurality of front-rear differential pressure values over a predetermined range and are acquired in advance, and outputs a fuel supply amount, which corresponds to the front-rear differential pressure, to the selection switch 8f as a first control amount S1 by searching the data group on the basis of the front-rear differential pressure input from the differential pressure gauge 7. That is, the differential pressure-fuel supply amount conversion table 8a outputs the amount of fuel (fuel supply amount) to be supplied to the fuel nozzles N (gas turbine G) from the fuel supply apparatus F, which is generated due to a specific front-rear differential pressure, to the selection switch 8f as the first control amount S1. The differential pressure-fuel supply amount conversion table 8a is a first control amount generation unit that generates the first control amount S1 on the basis of the front-rear differential pressure input from the differential pressure gauge 7.

[0020] The rotation speed-fuel supply amount conversion table 8b is a control table showing a relationship between the motor-rotation speed that is input from the electric motor 4 as the first detection signal and the fuel supply amount. That is, the rotation speed-fuel supply amount conversion table 8b includes a plurality of fuel supply amount data (data group) that correspond to a plurality of motor-rotation speed values over a predetermined range and are acquired in advance, and outputs a fuel supply amount, which corresponds to the motor-rotation speed, by searching the data group on the basis of the motor-rotation speed input from the electric motor 4. That is, the rotation speed-fuel supply amount conversion table 8b outputs the amount of fuel (fuel supply amount) to be supplied to the fuel nozzles N (gas turbine

G) from the fuel supply apparatus F which is generated due to a specific motor-rotation speed.

[0021] The leakage amount estimation unit 8c stores the estimation value of the leakage of fuel acquired in advance about the gear pump (positive-displacement pump) that is the high-pressure pump 3. The leakage of liquid to be discharged is generally small in the gear pump and the gear pump is excellent in linearity between a rotation speed and the amount of discharged liquid, but liquid may slightly leak from the gear pump due to a secular change or the like. The leakage amount estimation unit 8c calculates the estimation value of the leakage amount of fuel (leakage estimation value) on the basis of, for example, the initial leakage of the high-pressure pump 3 and the change factor for leakage, such as the operating time of the high-pressure pump 3, and outputs the calculated estimation value to the adder 8d.

[0022] The adder 8d adds the leakage estimation value, which is input from the leakage amount estimation unit 8c, to the fuel supply amount, which is input from the rotation speed-fuel supply amount conversion table 8b, to correct the fuel supply amount, and outputs the corrected fuel supply amount, which is the result of the addition, to the selection switch 8f as a second control amount S2. That is, since the fuel supply amount corresponding to the motor-rotation speed is corrected by the leakage estimation value, the second control amount S2 represents a fuel supply amount that is closer to the actual amount of fuel discharged from the high-pressure pump 3 than the fuel supply amount corresponding to the motor-rotation speed.

[0023] The rotation speed-fuel supply amount conversion table 8b, the leakage amount estimation unit 8c, and the adder 8d constitute a second control amount generation unit that generates the second control amount S2 on the basis of a pump-rotation speed input from the electric motor 4.

[0024] The switching logic circuit 8e is a logic circuit that generates a switching signal C on the basis of the motor-rotation speed. That is, in a case where the motor-rotation speed is equal to or lower than a predetermined switching threshold, the switching logic circuit 8e generates a switching signal C causing the selection switch 8f to select the first control amount S1. In a case where the motor-rotation speed exceeds the switching threshold, the switching logic circuit 8e generates a switching signal C causing the selection switch 8f to select the second control amount S2 instead of the first control amount S1.

[0025] Here, the switching threshold is set to a motor-rotation speed that is immediately before the above-mentioned pressurizing valve 5 is opened. That is, in a state where the pressurizing valve 5 is closed, that is, in a low flow-rate range where the flow rate of fuel is relatively low, the switching logic circuit 8e generates a switching signal C causing the selection switch 8f to select the first control amount S1 and outputs the switching signal C to the selection switch 8f. On the other hand, in a state where the pressurizing valve 5 is opened from a state

immediately before the pressurizing valve 5 is opened, that is, in a high flow-rate range where the flow rate of fuel is relatively high, the switching logic circuit 8e generates a switching signal C causing the selection switch 8f to select the second control amount S2 and outputs the switching signal C to the selection switch 8f.

[0026] Further, to avoid the instability of a switching operation in a case where the motor-rotation speed changes near the switching threshold, that is, to avoid a phenomenon where the first control amount S1 and the second control amount S2 are frequently switched, the switching logic circuit 8e uses different values as a switching threshold employed in a case where the motor-rotation speed tends to increase and a switching threshold employed in a case where the motor-rotation speed tends to decrease. That is, the switching logic circuit 8e allows the switching operation between the first control amount S1 and the second control amount S2 to have hysteresis characteristics.

[0027] The selection switch 8f alternatively selects the first control amount S1 or the second control amount S2 on the basis of the switching signal C. The selection switch 8f outputs the control amount, which is selected by the selection switch 8f, (the first control amount S1 or the second control amount S2) to the subtractor 8g. The selection switch 8f and the switching logic circuit 8e constitute a control amount selection unit of this embodiment.

[0028] The subtractor 8g calculates a deviation (fuel supply amount deviation) of the output (fuel supply amount) of the selection switch 8f from the control target value (the control target value about the flow rate of fuel) input from FADEC, and outputs the fuel supply amount deviation to the control calculation unit 8h. The control calculation unit 8h generates an operation amount of the electric motor 4 by performing predetermined calculation processing (PID calculation processing) on the fuel supply amount deviation input from the subtractor 8g. Here, since the high-pressure pump 3 is rotationally driven by the electric motor 4, the operation amount generated by the control calculation unit 8h is the operation amount of the electric motor 4 and is also the operation amount of the high-pressure pump 3.

[0029] Subsequently, the operation of the fuel supply control device 8 according to this embodiment will be described in detail.

[0030] The fuel supply control device 8 generates an operation amount of the electric motor 4 (high-pressure pump 3) to allow a fuel supply amount to be equal to the control target value and outputs the operation amount to the high-pressure pump 3 (fuel supply pump) to perform the feedback control of the high-pressure pump 3 as a basic operation. That is, a deviation calculated by the subtractor 8g of the fuel supply control device 8 is input to the control calculation unit 8h, so that an operation amount allowing the fuel supply amount to be equal to the control target value is generated.

[0031] Here, in the fuel supply control device 8, the first control amount S1 or the second control amount S2 se-

lected by the selection switch 8f is input to the subtractor 8g as a control amount. Further, the selection of the control amount performed by the selection switch 8f is performed on the basis of the switching signal C. The switching signal C causes the selection switch 8f to select the first control amount S 1 in a case where the motor-rotation speed is equal to or lower than a predetermined switching threshold, and causes the selection switch 8f to select the second control amount S2 instead of the first control amount S1 in a case where the motor-rotation speed exceeds the switching threshold.

[0032] That is, in a case where the motor-rotation speed is equal to or lower than the switching threshold, that is, in a low-flow rate range where the pressurizing valve 5 is closed and a fuel supply amount is relatively small, the feedback control of the high-pressure pump 3 is performed so that the first control amount S 1 generated by the differential pressure-fuel supply amount conversion table 8a (first control amount generation unit) on the basis of a front-rear differential pressure across the metering valve is equal to the control target value.

[0033] On the other hand, in a case where the motor-rotation speed exceeds the switching threshold, that is, in a high flow-rate range where a fuel supply amount is relatively large which is in a state where the pressurizing valve 5 is opened from a state immediately before the pressurizing valve 5 is opened, the feedback control of the high-pressure pump 3 is performed so that the second control amount S2 generated by the second control amount generation unit (the rotation speed-fuel supply amount conversion table 8b, the leakage amount estimation unit 8c, and the adder 8d) on the basis of the motor-rotation speed and the leakage estimation value without using the front-rear differential pressure across the metering valve is equal to the control target value.

[0034] According to this embodiment, since the feedback control of the high-pressure pump 3 is performed using the second control amount S2 generated on the basis of the motor-rotation speed and the leakage estimation value in a high flow-rate range after the pressurizing valve 5 is opened, stable fuel supply control can be achieved in the high flow-rate range.

[0035] Further, according to this embodiment, since the feedback control of the high-pressure pump 3 is performed using the first control amount S1 generated on the basis of the front-rear differential pressure across the metering valve in a low flow-rate range where the pressurizing valve 5 is closed, stable fuel supply control can be achieved even in the low flow-rate range.

[0036] Furthermore, according to this embodiment, since the first control amount S1 is generated using the differential pressure-fuel supply amount conversion table 8a (first control amount generation unit), the first control amount S 1 is a control amount that corresponds to an actual fuel supply amount with high accuracy. Therefore, according to this embodiment, highly accurate fuel supply control can be achieved in a low flow-rate range before the pressurizing valve 5 is opened.

[0037] Further, according to this embodiment, since the second control amount S2 is generated using the rotation speed-fuel supply amount conversion table 8b, the second control amount S2 is a control amount that corresponds to an actual fuel supply amount with high accuracy. Therefore, according to this embodiment, highly accurate fuel supply control can be achieved in a high flow-rate range after the pressurizing valve 5 is opened.

[0038] Furthermore, according to this embodiment, since the leakage amount estimation unit 8c and the adder 8d are provided in addition to the rotation speed-fuel supply amount conversion table 8b, the second control amount S2 based on not only the motor-rotation speed but also the leakage estimation value is generated. Therefore, according to this embodiment, a fuel supply amount corresponding to an actual fuel supply amount with high accuracy can be generated. As a result, more highly accurate fuel supply control can be achieved in a high flow-rate range after the pressurizing valve 5 is opened.

[0039] The disclosure is not limited to each embodiment, and, for example, the following modification examples are considered.

(1) The motor-rotation speed is treated as the rotation speed of the fuel supply pump in the embodiment, but the disclosure is not limited thereto. For example, a rotation sensor for detecting the rotation speed of the high-pressure pump 3 may be provided and the output of the rotation sensor may be taken as the rotation speed of the fuel supply pump.

[0040] Further, as shown in FIG. 3 showing a modification example of the embodiment of the disclosure, a signal (engine rotation speed signal) representing the rotation speed of the gas turbine G may be taken from FADEC. In this case, the switching logic circuit 8e of the embodiment may be a logic circuit that generates a switching signal C on the basis of the rotation speed of the gas turbine G instead of the motor-rotation speed. Further, the selection switch 8f may alternatively select the first control amount S 1 or the second control amount S2 on the basis of the switching signal C and the rotation speed of the gas turbine G instead of the motor-rotation speed. Even in this case, the selection switch 8f and the switching logic circuit 8e constitute a control amount selection unit of the modification example of the embodiment of the disclosure. Since other configuration is the same as that of the embodiment, detailed description thereof will be omitted.

[0041] (2) The control calculation unit 8h performing PID calculation processing on a fuel supply amount deviation is employed in the embodiment, but the disclosure is not limited thereto. Various kinds of processing are considered as the control calculation processing of the control calculation unit 8h in addition to simple PID calculation processing.

[0042] (3) The gas turbine G is a destination to which fuel is supplied in the embodiment, but the disclosure is not limited thereto.

Industrial Applicability

[0043] According to the fuel supply control device of the disclosure, stable fuel supply control can be achieved in a high flow-rate range after the pressurizing valve is opened.

Reference Signs List

[0044]

F	Fuel supply apparatus	
G	Gas turbine	
N	Fuel nozzle	
1	Fuel tank	
2	Low-pressure pump	
3	High-pressure pump (fuel supply pump)	
4	Electric motor	
5	Pressurizing valve	
6	Orifice	
7	Differential pressure gauge	
8	Fuel supply control device	
8a	Differential pressure-fuel supply amount conversion table (first control amount generation unit)	
8b	Rotation speed-fuel supply amount conversion table (second control amount generation unit)	
8c	Leakage amount estimation unit (second control amount generation unit)	
8d	Adder (second control amount generation unit)	
8e	Switching logic circuit (control amount selection unit)	
8f	Selection switch (control amount selection unit)	
8g	Subtractor	
8h	Control calculation unit	

Claims

1. A fuel supply control device (8) for a gas turbine (G) that is configured to control a fuel supply pump (3) on the basis of a front-rear differential pressure across a metering valve for a fuel supply amount, which is detected by a differential pressure gauge (7), using parallel flow passages of an orifice (6) and a pressurizing valve (5) as the metering valve, the fuel supply control device (8) comprising:
 - a first control amount generation unit (8a) that is configured to generate a first control amount on the basis of the front-rear differential pressure; and
 - a second control amount generation unit (8b, 8c, 8d) that is configured to generate a second control amount on the basis of a rotation speed of

the fuel supply pump (3), **characterized in that** the fuel supply control device (8) further comprises:

a control amount selection unit (8e, 8f) that is configured to alternatively select the first control amount or the second control amount on the basis of the rotation speed and to output the selected control amount; a subtractor (8g) that is configured to calculate a deviation of an output of the control amount selection unit (8e, 8f) from a control target value and to output the deviation; and a control calculation unit (8h) that is configured to calculate an operation amount of the fuel supply pump (3) on the basis of an output of the subtractor (8g), wherein the control amount selection unit (8e, 8f) is configured to select the first control amount in a case where the rotation speed is equal to or lower than a predetermined threshold and to select the second control amount instead of the first control amount in a case where the rotation speed exceeds the threshold.

2. The fuel supply control device (8) according to claim 1, wherein the first control amount generation unit (8a) is configured to generate the first control amount on the basis of a differential pressure-fuel supply amount conversion table (8a) showing a relationship between the front-rear differential pressure and a flow rate of fuel.
3. The fuel supply control device (8) according to claim 1 or 2, wherein the second control amount generation unit (8b) is configured to generate the second control amount on the basis of a rotation speed-fuel supply amount conversion table (8b) showing a relationship between the rotation speed and a flow rate of fuel.
4. The fuel supply control device (8) according to claim 3, wherein the second control amount generation unit (8b) is configured to generate the second control amount by correcting an output of the rotation speed-fuel supply amount conversion table (8b) on the basis of an estimation value of leakage amount of fuel acquired in advance about the fuel supply pump (3).
5. The fuel supply control device (8) according to any one of claims 1 to 4, wherein the second control amount generation unit (8b) is configured to generate the second control amount by taking a rotation speed of a motor (4), which drives the fuel supply pump (3), as the rotation

speed of the fuel supply pump (3).

6. A fuel supply control device (8) for a gas turbine (G) that is configured to control a fuel supply pump (3) on the basis of a front-rear differential pressure across a metering valve for a fuel supply amount, which is detected by a differential pressure gauge (7), using parallel flow passages of an orifice (6) and a pressurizing valve (5) as the metering valve, the fuel supply control device (8) comprising:

a first control amount generation unit (8a) that is configured to generate a first control amount on the basis of the front-rear differential pressure; and
a second control amount generation unit (8b, 8c, 8d) that is configured to generate a second control amount on the basis of a rotation speed of the fuel supply pump (3), **characterized in that** the fuel supply control device (8) further comprises:

a control amount selection unit (8e, 8f) that is configured to alternatively select the first control amount or the second control amount on the basis of a rotation speed of the gas turbine (G) and to output the selected control amount;

a subtractor (8g) that is configured to calculate a deviation of the output of the control amount selection unit (8e, 8f) from a control target value and to output the deviation; and
a control calculation unit (8h) that is configured to calculate an operation amount of the fuel supply pump (3) on the basis of the output of the subtractor (8g),

wherein the control amount selection unit (8e, 8f) is configured to select the first control amount in a case where the rotation speed of the gas turbine is equal to or lower than a predetermined threshold and to select the second control amount instead of the first control amount in a case where the rotation speed of the gas turbine exceeds the threshold.

7. The fuel supply control device (8) according to claim 6,
wherein the first control amount generation unit (8a) is configured to generate the first control amount on the basis of a differential pressure-fuel supply amount conversion table (8a) showing a relationship between the front-rear differential pressure and a flow rate of fuel.
8. The fuel supply control device (8) according to claim 6 or 7,
wherein the second control amount generation unit

(8b) is configured to generate the second control amount on the basis of a rotation speed-fuel supply amount conversion table (8b) showing a relationship between the rotation speed and a flow rate of fuel.

9. The fuel supply control device (8) according to claim 8,
wherein the second control amount generation unit (8b) is configured to generate the second control amount by correcting an output of the rotation speed-fuel supply amount conversion table (8b) on the basis of an estimation value of leakage amount of fuel acquired in advance about the fuel supply pump (3).
10. The fuel supply control device (8) according to any one of claims 6 to 9,
wherein the second control amount generation unit (8b) is configured to generate the second control amount by taking a rotation speed of a motor (4), which drives the fuel supply pump (3), as the rotation speed of the fuel supply pump (3).

11. The fuel supply control device (8) according to any one of claims 1 to 10,
wherein the control calculation unit (8h) is configured to calculate the operation amount of the fuel supply pump (3) by performing PID calculation processing on the output of the subtractor (8g).

Patentansprüche

1. Kraftstoffversorgungssteuervorrichtung (8) für eine Gasturbine (G), die konfiguriert ist, eine Kraftstoffversorgungspumpe (3) basierend auf einem von einem Differenzdruckmesser (7) detektierten Vorderseite-Rückseiten-Differenzdruck über ein Dosierventil für eine Kraftstoffversorgungs menge hinweg unter Verwendung von parallelen Strömungskanälen einer Messblende (6) und eines Druckbeaufschlagungsventils (5) als das Dosierventil zu steuern, wobei die Kraftstoffversorgungssteuervorrichtung (8) umfasst:

eine erste Steuergrößenerzeugungseinheit (8a), die konfiguriert ist, basierend auf dem Vorderseite-Rückseiten-Differenzdruck eine erste Steuergröße zu erzeugen; und

eine zweite Steuergrößenerzeugungseinheit (8b, 8c, 8d), die konfiguriert ist, basierend auf einer Drehzahl der Kraftstoffversorgungspumpe (3) eine zweite Steuergröße zu erzeugen, **dadurch gekennzeichnet, dass**

die Kraftstoffversorgungssteuervorrichtung (8) ferner umfasst:

eine Steuergrößenauswahleinheit (8e, 8f), die konfiguriert ist, die erste Steuergröße

- oder die zweite Steuergröße basierend auf der Drehzahl alternativ auszuwählen und die ausgewählte Steuergröße auszugeben; einen Subtrahierer (8g), der konfiguriert ist, eine Abweichung einer Ausgabe der Steuergrößenauswahleinheit (8e, 8f) von einem Steuersollwert zu berechnen und die Abweichung auszugeben; und eine Steuerberechnungseinheit (8h), die konfiguriert ist, eine Betriebsmenge der Kraftstoffversorgungspumpe (3) basierend auf einer Ausgabe des Subtrahierers (8g) zu berechnen, wobei die Steuergrößenauswahleinheit (8e, 8f) konfiguriert ist, in einem Fall, in dem die Drehzahl gleich oder niedriger als ein vorbestimmter Schwellenwert ist, die erste Steuergröße auszuwählen und in einem Fall, in dem die Drehzahl den Schwellenwert überschreitet, anstelle der ersten Steuergröße die zweite Steuergröße auszuwählen.
2. Kraftstoffversorgungssteuervorrichtung (8) nach Anspruch 1, wobei die erste Steuergrößenerzeugungseinheit (8a) konfiguriert ist, die erste Steuergröße basierend auf einer Differenzdruck-Kraftstoffversorgungs-mengen-Umrechnungstabelle (8a) zu erzeugen, die eine Beziehung zwischen dem Vorderseite-Rückseiten-Differenzdruck und einer Kraftstoffströmungsgeschwindigkeit zeigt.
3. Kraftstoffversorgungssteuervorrichtung (8) nach Anspruch 1 oder 2, wobei die zweite Steuergrößenerzeugungseinheit (8b) konfiguriert ist, die zweite Steuergröße basierend auf einer Drehzahl-Kraftstoffversorgungs-mengen-Umrechnungstabelle (8b) zu erzeugen, die eine Beziehung zwischen der Drehzahl und einer Kraftstoffströmungsgeschwindigkeit zeigt.
4. Kraftstoffversorgungssteuervorrichtung (8) nach Anspruch 3, wobei die zweite Steuergrößenerzeugungseinheit (8b) konfiguriert ist, die zweite Steuergröße zu erzeugen, indem sie eine Ausgabe der Drehzahl-Kraftstoffversorgungsmengen-Umrechnungstabelle (8b) basierend auf einem im Voraus über die Kraftstoffversorgungspumpe (3) erlangten Leckagemengenschätzwert des Kraftstoffs korrigiert.
5. Kraftstoffversorgungssteuervorrichtung (8) nach einem der Ansprüche 1 bis 4, wobei die zweite Steuergrößenerzeugungseinheit (8b) konfiguriert ist, die zweite Steuergröße zu erzeugen, indem sie eine Drehzahl eines Motors (4), der die Kraftstoffversorgungspumpe (3) antreibt, als die Drehzahl der Kraftstoffversorgungspumpe (3) verwendet.
6. Kraftstoffversorgungssteuervorrichtung (8) für eine Gasturbine (G), die konfiguriert ist, eine Kraftstoffversorgungspumpe (3) basierend auf einem von einem Differenzdruckmesser (7) detektierten Vorderseite-Rückseiten-Differenzdruck über ein Dosier-ventil für eine Kraftstoffversorgungs-menge hinweg unter Verwendung von parallelen Strömungskanälen einer Messblende (6) und eines Druckbeaufschlagungsventils (5) als das Dosier-ventil zu steuern, wobei die Kraftstoffversorgungssteuervorrichtung (8) umfasst:
- eine erste Steuergrößenerzeugungseinheit (8a), die konfiguriert ist, basierend auf dem Vorderseite-Rückseiten-Differenzdruck eine erste Steuergröße zu erzeugen; und eine zweite Steuergrößenerzeugungseinheit (8b, 8c, 8d), die konfiguriert ist, basierend auf einer Drehzahl der Kraftstoffversorgungspumpe (3) eine zweite Steuergröße zu erzeugen, **dadurch gekennzeichnet, dass** die Kraftstoffversorgungssteuervorrichtung (8) ferner umfasst:
- eine Steuergrößenauswahleinheit (8e, 8f), die konfiguriert ist, die erste Steuergröße oder die zweite Steuergröße basierend auf einer Drehzahl der Gasturbine (G) alternativ auszuwählen und die ausgewählte Steuergröße auszugeben; einen Subtrahierer (8g), der konfiguriert ist, eine Abweichung der Ausgabe der Steuergrößenauswahleinheit (8e, 8f) von einem Steuersollwert zu berechnen und die Abweichung auszugeben; und eine Steuerberechnungseinheit (8h), die konfiguriert ist, eine Betriebsmenge der Kraftstoffversorgungspumpe (3) basierend auf der Ausgabe des Subtrahierers (8g) zu berechnen, wobei die Steuergrößenauswahleinheit (8e, 8f) konfiguriert ist, in einem Fall, in dem die Drehzahl der Gasturbine gleich oder niedriger als ein vorbestimmter Schwellenwert ist, den ersten Steuerbetrag auszuwählen und in einem Fall, in dem die Drehzahl der Gasturbine den Schwellenwert überschreitet, anstelle des ersten Steuerbetrags den zweiten Steuerbetrag auszuwählen.
7. Kraftstoffversorgungssteuervorrichtung (8) nach Anspruch 6, wobei die erste Steuergrößenerzeugungseinheit (8a) konfiguriert ist, die erste Steuergröße basierend auf einer Differenzdruck-Kraftstoffversorgungs-mengen-Umrechnungstabelle (8a) zu erzeugen, die eine Beziehung zwischen dem Vorderseite-Rückseiten-Differenzdruck und einer Kraftstoffströmungsgeschwindigkeit zeigt.

gen-Umrechnungstabelle (8a) zu erzeugen, die eine Beziehung zwischen dem Vorderseite-Rückseiten-Differenzdruck und einer Kraftstoffströmungsgeschwindigkeit zeigt.

8. Kraftstoffversorgungssteuervorrichtung (8) nach Anspruch 6 oder 7,
wobei die zweite Steuergrößenerzeugungseinheit (8b) konfiguriert ist, die zweite Steuergröße basierend auf einer Drehzahl-Kraftstoffversorgungsmengen-Umrechnungstabelle (8b) zu erzeugen, die eine Beziehung zwischen der Drehzahl und einer Kraftstoffströmungsgeschwindigkeit zeigt. 5
9. Kraftstoffversorgungssteuervorrichtung (8) nach Anspruch 8,
wobei die zweite Steuergrößenerzeugungseinheit (8b) konfiguriert ist, die zweite Steuergröße zu erzeugen, indem sie eine Ausgabe der Drehzahl-Kraftstoffversorgungsmengen-Umrechnungstabelle (8b) basierend auf einem im Voraus über die Kraftstoffversorgungspumpe (3) erlangten Leckagemengenschätzwert des Kraftstoffs korrigiert. 10
10. Kraftstoffversorgungssteuervorrichtung (8) nach einem der Ansprüche 6 bis 9,
wobei die zweite Steuergrößenerzeugungseinheit (8b) konfiguriert ist, die zweite Steuergröße zu erzeugen, indem sie eine Drehzahl eines Motors (4), der die Kraftstoffversorgungspumpe (3) antreibt, als die Drehzahl der Kraftstoffversorgungspumpe (3) verwendet. 15
11. Kraftstoffversorgungssteuervorrichtung (8) nach einem der Ansprüche 1 bis 10,
wobei die Steuerberechnungseinheit (8b) konfiguriert ist, die Betriebsmenge der Kraftstoffversorgungspumpe (3) zu berechnen, indem sie eine PID-Berechnungsverarbeitung an der Ausgabe des Subtrahierers (8g) ausführt. 20

Revendications

1. Dispositif de commande d'alimentation en carburant (8) pour une turbine à gaz (G) qui est configuré pour commander une pompe d'alimentation en carburant (3) en se basant sur une pression différentielle avant-arrière à travers une soupape doseuse pour une quantité d'alimentation en carburant qui est détectée par un manomètre différentiel (7), utilisant des passages d'écoulement parallèles d'un orifice (6) et d'une soupape de mise en pression (5) en tant que la soupape doseuse, le dispositif de commande d'alimentation en carburant (8) comprenant : 25

une première unité de génération de quantité de commande (8a) qui est configurée pour générer

une première quantité de commande en se basant sur la pression différentielle avant-arrière ; et

une seconde unité de génération de quantité de commande (8b, 8c, 8d) qui est configurée pour générer une seconde quantité de commande en se basant sur une vitesse de rotation de la pompe d'alimentation en carburant (3), **caractérisé en ce que**

le dispositif de commande d'alimentation en carburant (8) comprend en outre :

une unité de sélection de quantité de commande (8e, 8f) qui est configurée pour sélectionner alternativement la première quantité de commande ou la seconde quantité de commande en se basant sur la vitesse de rotation et pour sortir la quantité de commande sélectionnée ;

un soustracteur (8g) qui est configuré pour calculer un écart d'une sortie de l'unité de sélection de quantité de commande (8e, 8f) à partir d'une valeur cible de commande et pour sortir l'écart ; et

une unité de calcul de commande (8h) qui est configurée pour calculer une quantité de fonctionnement de la pompe d'alimentation en carburant (3) en se basant sur une sortie du soustracteur (8g),

dans lequel l'unité de sélection de quantité de commande (8e, 8f) est configurée pour sélectionner la première quantité de commande dans un cas où la vitesse de rotation est inférieure ou égale à un seuil prédéterminé et pour sélectionner la seconde quantité de commande au lieu de la première quantité de commande dans un cas où la vitesse de rotation dépasse le seuil.

2. Dispositif de commande d'alimentation en carburant (8) selon la revendication 1,
dans lequel la première unité de génération de quantité de commande (8a) est configurée pour générer la première quantité de commande en se basant sur un tableau de conversion de quantité d'alimentation en carburant-pression différentielle (8a) montrant un lien entre la pression différentielle avant-arrière et un débit de carburant. 30

3. Dispositif de commande d'alimentation en carburant (8) selon la revendication 1 ou 2,
dans lequel la seconde unité de génération de quantité de commande (8b) est configurée pour générer la seconde quantité de commande en se basant sur un tableau de conversion de quantité d'alimentation en carburant-vitesse de rotation (8b) montrant un lien entre la vitesse de rotation et un débit de carburant. 35

4. Dispositif de commande d'alimentation en carburant (8) selon la revendication 3, dans lequel la seconde unité de génération de quantité de commande (8b) est configurée pour générer la seconde quantité de commande en corrigeant une sortie du tableau de conversion de quantité d'alimentation carburant-vitesse de rotation (8b) en se basant sur une valeur d'estimation d'une quantité de fuite de carburant acquise en avance concernant la pompe d'alimentation en carburant (3). 5 10
5. Dispositif de commande d'alimentation en carburant (8) selon l'une quelconque des revendications 1 à 4, dans lequel la seconde unité de génération de quantité de commande (8b) est configurée pour générer la seconde quantité de commande en prenant une vitesse de rotation d'un moteur (4) qui entraîne la pompe d'alimentation en carburant (3) en tant que la vitesse de rotation de la pompe d'alimentation en carburant (3). 15 20
6. Dispositif de commande d'alimentation en carburant (8) pour une turbine à gaz (G) qui est configuré pour commander une pompe d'alimentation en carburant (3) en se basant sur une pression différentielle avant-arrière à travers une soupape doseuse pour une quantité d'alimentation en carburant qui est détectée par un manomètre différentiel (7), utilisant des passages d'écoulement parallèles d'un orifice (6) et d'une soupape de mise en pression (5) en tant que la soupape doseuse, le dispositif de commande d'alimentation en carburant (8) comprenant : 25 30

une première unité de génération de quantité de commande (8a) qui est configurée pour générer une première quantité de commande en se basant sur la pression différentielle avant-arrière ; et 35

une seconde unité de génération de quantité de commande (8b, 8c, 8d) qui est configurée pour générer une seconde quantité de commande en se basant sur une vitesse de rotation de la pompe d'alimentation en carburant (3), **caractérisé en ce que** 40

le dispositif de commande d'alimentation en carburant (8) comprend en outre : 45

une unité de sélection de quantité de commande (8e, 8f) qui est configurée pour sélectionner alternativement la première quantité de commande ou la seconde quantité de commande en se basant sur une vitesse de rotation de la turbine à gaz (G) et pour sortir la quantité de commande sélectionnée ; 50

un soustracteur (8g) qui est configuré pour calculer un écart de la sortie de l'unité de sélection de quantité de commande (8e, 8f) 55
- à partir d'une valeur cible de commande et pour sortir l'écart ; et 60
- une unité de calcul de commande (8h) qui est configurée pour calculer une quantité de fonctionnement de la pompe d'alimentation en carburant (3) en se basant sur la sortie du soustracteur (8g), 65
- dans lequel l'unité de sélection de quantité de commande (8e, 8f) est configurée pour sélectionner la première quantité de commande dans un cas où la vitesse de rotation de la turbine à gaz est inférieure ou égale à un seuil prédéterminé et pour sélectionner la seconde quantité de commande au lieu de la première quantité de commande dans un cas où la vitesse de rotation de la turbine à gaz dépasse le seuil. 70
7. Dispositif de commande d'alimentation en carburant (8) selon la revendication 6, dans lequel la première unité de génération de quantité de commande (8a) est configurée pour générer la première quantité de commande en se basant sur un tableau de conversion de quantité d'alimentation carburant-pression différentielle (8a) montrant un lien entre la pression différentielle avant-arrière et un débit de carburant. 75
8. Dispositif de commande d'alimentation en carburant (8) selon la revendication 6 ou 7, dans lequel la seconde unité de génération de quantité de commande (8b) est configurée pour générer la seconde quantité de commande en se basant sur un tableau de conversion de quantité d'alimentation carburant-vitesse de rotation (8b) montrant un lien entre la vitesse de rotation et un débit de carburant. 80
9. Dispositif de commande d'alimentation en carburant (8) selon la revendication 8, dans lequel la seconde unité de génération de quantité de commande (8b) est configurée pour générer la seconde quantité de commande en corrigeant une sortie du tableau de conversion de quantité d'alimentation carburant-vitesse de rotation (8b) en se basant sur une valeur d'estimation d'une quantité de fuite de carburant acquise en avance concernant la pompe d'alimentation en carburant (3). 85
10. Dispositif de commande d'alimentation en carburant (8) selon l'une quelconque des revendications 6 à 9, dans lequel la seconde unité de génération de quantité de commande (8b) est configurée pour générer la seconde quantité de commande en prenant une vitesse de rotation d'un moteur (4) qui entraîne la pompe d'alimentation en carburant (3) en tant que la vitesse de rotation de la pompe d'alimentation en carburant (3). 90

11. Dispositif de commande d'alimentation en carburant (8) selon l'une quelconque des revendications 1 à 10, dans lequel l'unité de calcul de commande (8b) est configurée pour calculer la quantité de fonctionnement de la pompe d'alimentation en carburant (3) en effectuant un traitement par calcul PID sur la sortie du soustracteur (8g).

5

10

15

20

25

30

35

40

45

50

55

FIG. 1

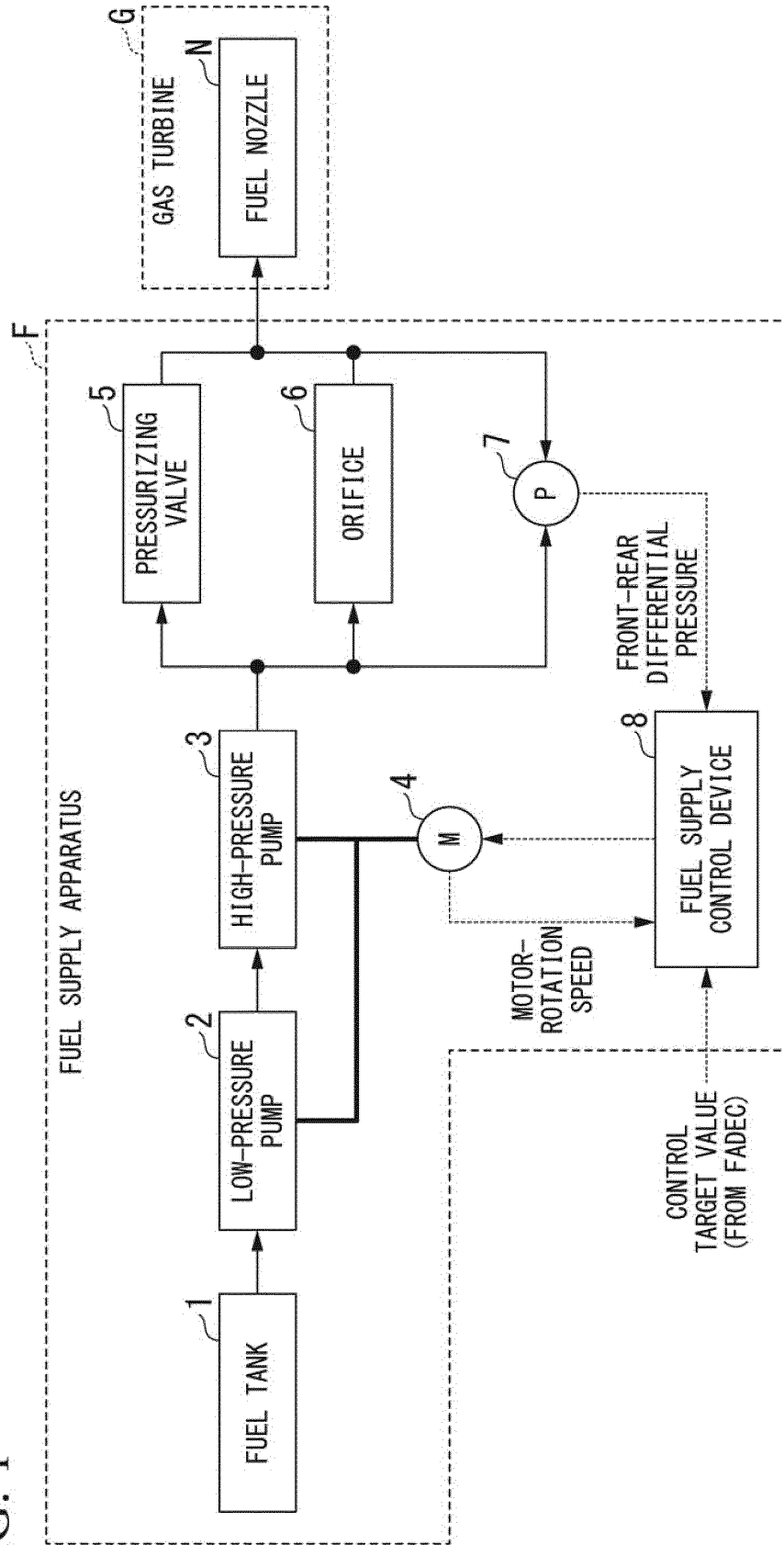


FIG. 2

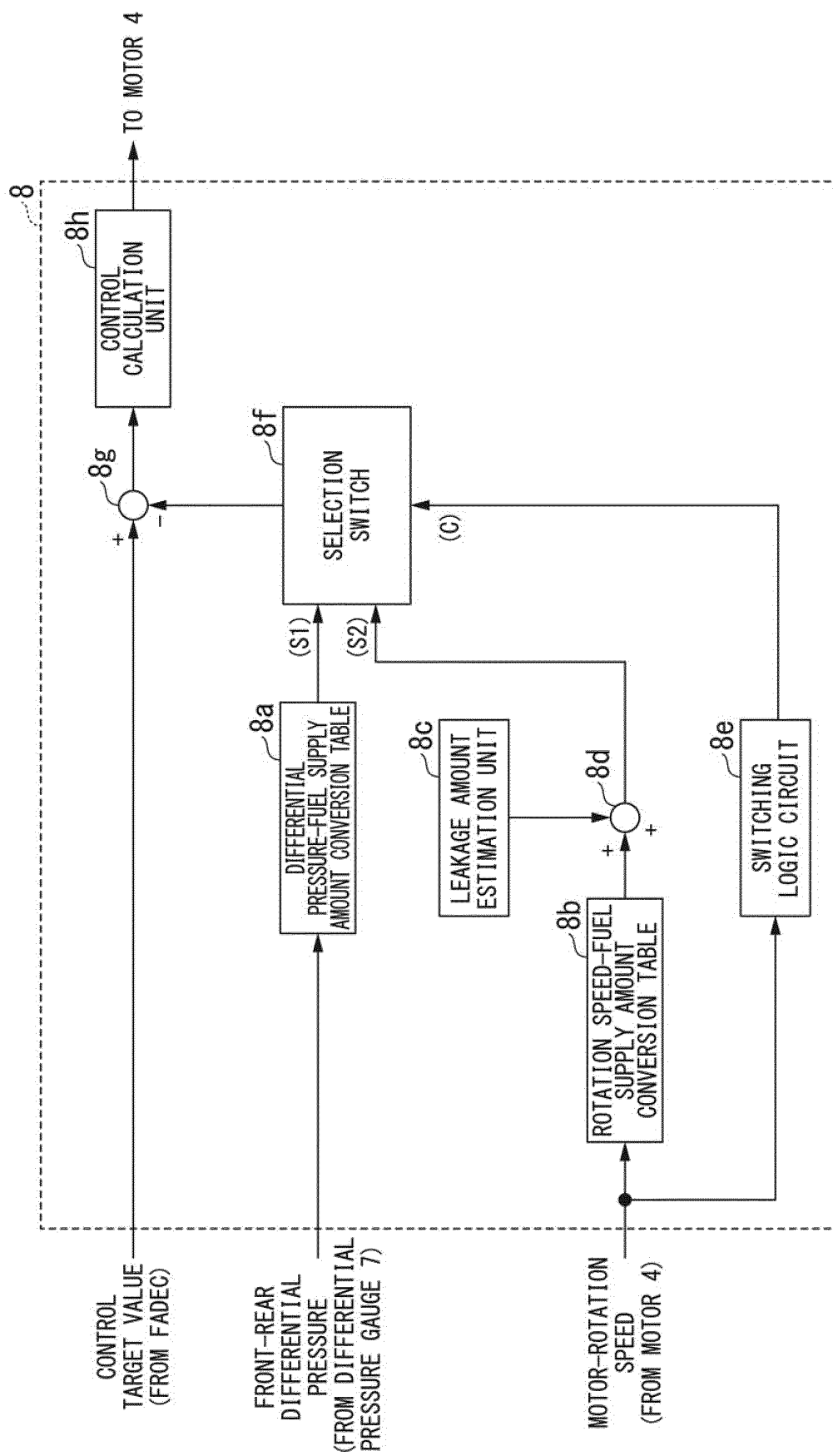
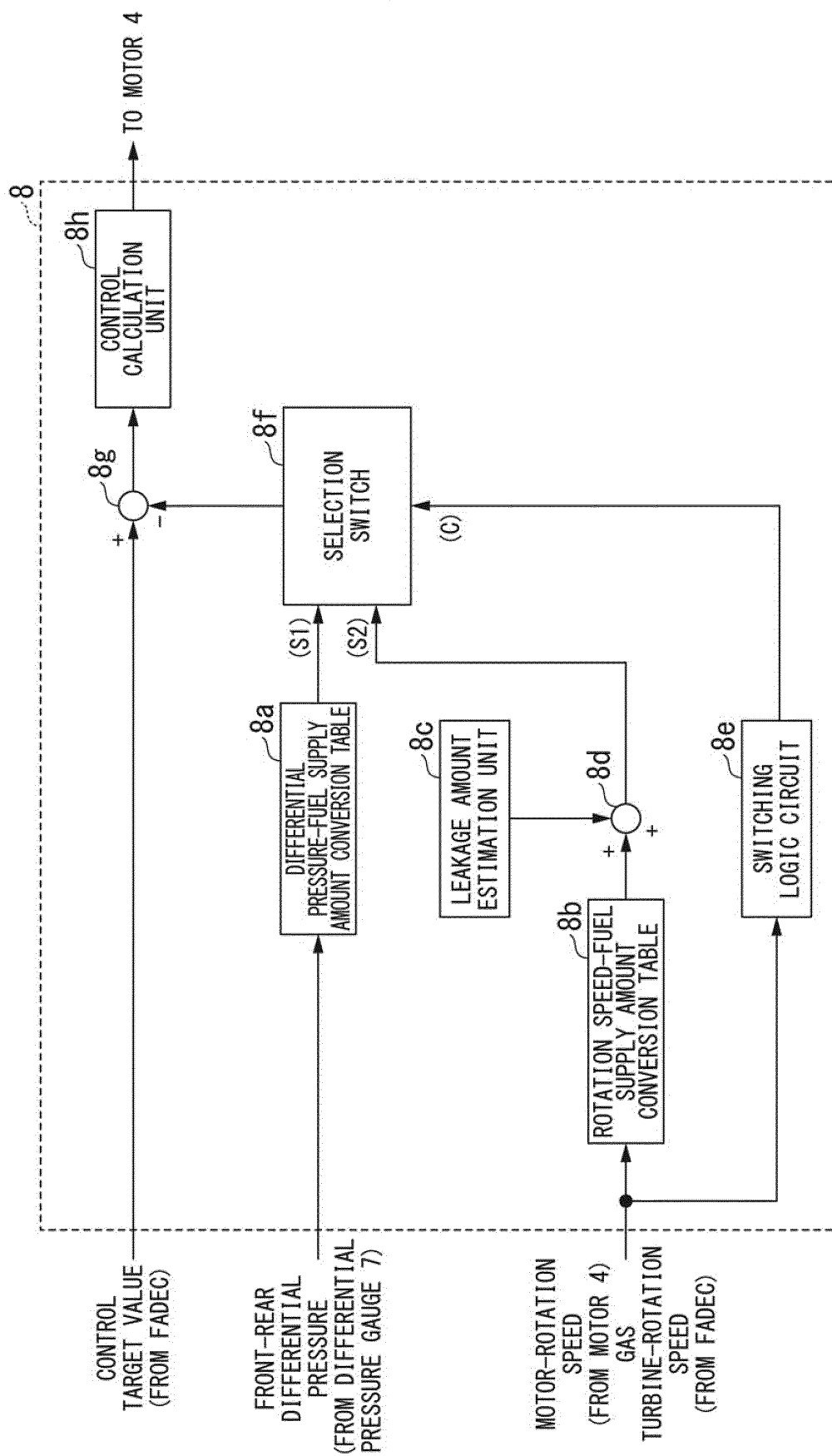


FIG. 3



REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- GB 2351777 A [0001]
- JP 2013231406 A [0002]